Three

Diameter-Limit Cuttings

in West Virginia Hardwoods

a 5-year report

by Russell J. Hutnik

STATION PAPER NO. 106 • NORTHEASTERN FOREST EXPERIMENT STATION • 1958

FOREST SERVICE • U.S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA.

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Cutting Methods Tested

MINE timbers are a basic need of West Virginia's giant coal industry. The annual requirement of sawed mine timbers is roughly 250 million board feet *(1)*. The mines also use a large volume of wood in rough form for props and lagging. Yet, compared to sawlogs and veneer logs, these mine timbers are low-value products. This means that they must be produced at low cost.

In an attempt to evaluate diameter-limit cutting as an economical method of managing forests for the production of mine timbers, a study was begun in 1950 on the Fernow Experimental Forest near Parsons, West Virginia. Essentially this was a study to determine which of three diameter-limit cuttings was best suited for mine-timber production. Diameter-limit cuttings were selected because they can be used with a minimum of technical forestry supervision. Thus the cost of forest management can be kept low.

The three treatments used and the costs and returns from the first cut have been described by Weitzman *(3)*. Briefly the treatments were:

1. A 16-inch diameter limit. All merchantable trees larger than 16.5 inches d.b.h. were cut; all unmerchantable trees 4.5 inches or larger were girdled or poisoned. Skid-road grades did not exceed 10 percent, and water bars were placed as needed.

2. A 13-inch diameter limit. All merchantable trees larger than 13.5 inches d.b.h. were cut; again all cull trees 4.5 inches or larger were girdled or poisoned. Skid roads were laid out not to exceed a 20-percent grade, and water bars were installed after logging.

3. An 8-inch diameter limit. All trees larger than 8.5 inches d.b.h. were harvested. Merchantabletrees were cut; culls were girdled or poisoned. There was no planned system of skid roads or erosion control.

The Area Before Cutting

The study was carried out on three adjacent watersheds ranging in size from 46 to 59 acres. Forest stands on these watersheds reflected their past history. The area had been logged soon after the turn of the century; everything that the operator thought would yield a profit had been cut. Defective trees and trees of certain species such as sugar maple and beech were left. The coves, which contained the largest and best trees and were the easiest to log, were cut

Figure 1.--*Forest stand before cutting.*

heavily. The ridges and steep slopes, which supported poorer trees and were less accessible, were cut lightly. Fires followed the logging and many of the trees left standing were fire-scarred and developed butt rot.

So in 1950 the forest contained two distinct classes of trees--those left by the loggers, and those that grew in after the logging and fires. Figure 1 shows this stand in 1950. In general, the holdovers were the larger trees as well as the more defective and less accessible ones. The second-growth stands on the better sites contained many fine trees--red oak, yellow-poplar, black cherry, and basswood--in the 10-, 12-, and 14-inch diameter classes. The second-growth stands on poorer sites were composed mostly of oak, sassafras, and black locust in the 6- and 8-inch diameter classes. On the watersheds as a whole, the oaks, especially red oak and chestnut oak, were the predominant species.

Although the stands on all three areas were similar in most respects before cutting, there were some differences important enough to influence the growth pattern that followed cutting. Briefly, the stand differences were:

- The 16-inch diameter-limit area had a somewhat higher proportion of poor sites.

- Although each area had about 95 square feet of basal area per acre in trees larger than 4.5 inches d.b.h., the 13-inch area had less gross sawlog volume--7,600 board feet per acre compared to 8,600 on the other two.

- The 13-inch area had fewer large holdovers.

The Stands After Cutting

The 8-inch diameter-limit cut in many ways resembled a commercial clear-cut; all merchantable products were removed. Figure 2 illustrates how the 8-inch cut left the area. The residual growing stock totaled just over 20 square feet of basal area per acre and contained less than 400 cubic feet per acre. It differed from a commercial clear-cut in one important aspect: the cull trees were poisoned.

Figure 2.--*Residual stand after the 8-inch diameter cutting.*

Despite the difference in diameter limits, the stands left after the 13- and 16-inch cuts were similar in density of stocking. Each contained a little less than 60 square feet of basal area per acre and had a volume of about 1,200 cubic feet per acre. Only in board-foot volume did they differ. The 16-inch cutting area had over 3,000 board feet per acre; the 13-inch area less than 2,000 board feet per acre. Thus the stand structure was different. As compared to the 16-inch diameter limit cut, the 13-inch cut left considerably more pole-size trees, but, of course, no trees above 13.5 inches in diameter.

Although the culls were killed in each area, many trees of low vigor, poor quality, and undesirable species were left. This was especially true in the 16-inch cutting, where many 14- and 16-inch trees were holdovers from the original stand.

Growth

The 13-inch area grew best during the 5-year period following cutting (table 1). This was true even with board-foot growth, despite the fact that only two-thirds as much board-foot volume was left as in the 16-inch cutting.

Table 1.--Average annual growth rates per acre for the 5-year period after cutting

Diameter limit of cutting	Accretion	Ingrowth	Mortality	Net change
		Square feet of basal area*		
16-inch	1.77	0.65	0.29	2.13
13-inch	2.05	.66	.29	2.42
8-inch	1.34	1.12	.12	2.34
		Cubic-foot volume to a 4-inch top*		
16-inch	49	11	6	54
13-inch	58	11	6	63
8-inch	34	18	2	50
		Board-foot volume to an 8-inch top**		
16-inch	130	130	7	253
13-inch	108	174	5	277
8-inch	0	10	0	10

*In trees larger than 5.0 inches.

**In trees larger than 11.0 inches (International ¼-inch rule).

Of course, the area cut to an 8-inch limit had little board-foot growth. However, its basal area increased by 50 percent and the total amount of basal area increase was greater than that on the 16-inch cut.

The large amount of ingrowth caused the good showing of the 8-inch cutting; ingrowth was less important in the lighter cuts. Ingrowth in all areas was made up largely of the tolerant species--especially the maples. This was anticipated since most saplings in the original stand were in these species. Greater differences among the cuts are ex-

pected to appear later when the intolerant species that have come in following the cutting reach pole-size.

Mortality occurred in all three cuttings. The heaviest cut had the least mortality. However, when based on the growing stock at the beginning of the period, the percent of mortality was about the same in each area. Mortality was severest in small trees; especially overmature black locust and sassafras.

In areas of light cutting, some of the smaller intolerant trees died from suppression. Where cutting was heavy, some small black birch and black cherry died from sudden exposure.

So far growth data has been presented on an area basis only. How have individual trees reacted to the three different types of cutting? Average annual diameter growth by diameter classes helps answer this question (fig. 3). Diameter growth for the classes up to and including the 12-inch diameter class for both the 13-inch and the 16-inch cuttings closely follows the same trend. For these diameters, growth was slightly higher in the 13-inch limit. Above the 12-inch d.b.h. class, the growth curves departed radi-

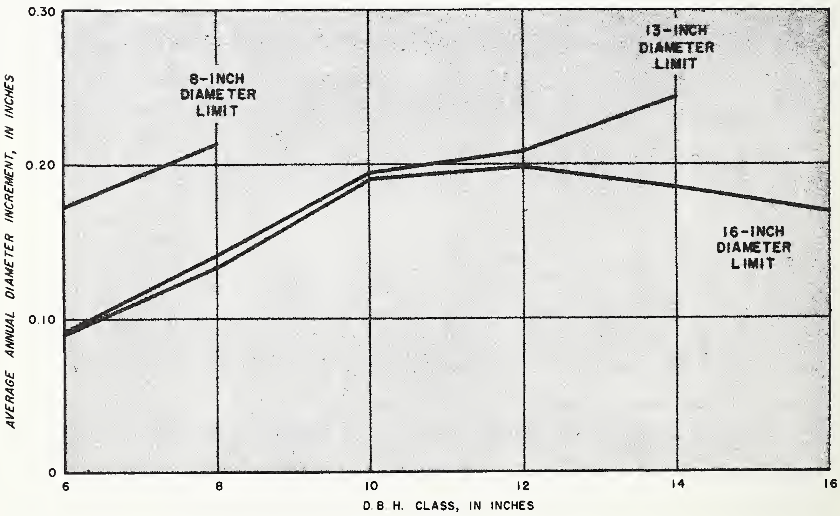

Figure 3.--*Average annual diameter increment by d.b.h. classes for the 5-year period after logging.*

cally. Trees in the 14-inch class on the 13-inch cutting grew faster than in any other class or cutting. On the 16-inch cutting, growth reached its peak in the 12-inch diameter class and fell off slightly in larger trees. Growth of 6- and 8-inch trees in the 8-inch diameter cutting was considerably higher than for trees of the same size in the lighter cuttings, but the trend was the same. Even so, most of these trees were still not growing as fast as the larger trees (10 inches and over) on the lighter cuttings.

Growth curves by diameter classes help explain the better growth following the 13-inch cutting as compared to the 16-inch cutting. As mentioned, both had about the same residual basal area, but the area cut to 13 inches had more good sites. The small differences in the two lighter-cut curves up to 12 inches probably reflect this fact. Above 12 inches the difference is mostly due to tree vigor. Two classes of trees were left in the area cut to 16 inches: (1) old holdovers of low vigor and (2) young, vigorous second-growth trees. The more holdovers cut, the better the average growth because slower-growing trees are removed from the stand and nearby trees are released. Cutting to a 13-inch diameter eliminated most all the old holdovers.

Reproduction Changes

Five years after cutting, a seedling-and-sapling survey showed that reproduction was plentiful and well-distributed in all compartments. There were at least 7,000 seedlings per acre between 1 foot in height and 1 inch in diameter (table 2).[1] In addition there were 400 to 600 saplings per acre.Although an abundance of seedlings and saplings followed all three cuttings, there were some important differences in quality of reproduction. For example, the 8-inch cutting resulted in a considerable proportion of saplings of sprout origin. These are very vigorous and already are dominating more desirable seedlings and saplings nearby.

Comparison of reproduction tallies before and 5 years after cutting shows only a few important changes in repro-

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[1]This is the definition used for “advance reproduction”.

Table 2.--Reproduction 5 years after cutting

Diameter limit of cutting	Milacres stocked	Seedlings per acre	Saplings per acre	Saplings of sprout origin per acre
	Percent	Number	Number	Number
16-inch	91	9,100	470	30
13-inch	88	7,400	400	40
8-inch	96	10,300	560	120

duction. The 13-inch compartment, sparsely stocked with advance reproduction before cutting, now has 88 percent of its milacres stocked with tree reproduction. As a result, almost all species have increased in the percent of milacres that they stock.

Reproduction data for the other two areas show how the cutting has changed the character of the well-stocked advance reproduction (table 3). Sugar maple was the most abundant and widespread reproduction both before and after cutting. Most of the sugar maple now on the areas is a result of advance stocking. Since some of this reproduction was destroyed in logging, the percent of stocking is somewhat lower after than before cutting on both areas.

Another common species in the post-logging stand is sassafras. The stocking of this species increased after cutting, and heavy cutting resulted in the largest increase.

Table 3.--Percentage of milacres stocked both before and 5 years after cuttings[1/]

Species	16-inch compartment		13-inch compartment		8-inch compartment	
	Before cutting	5 years after cutting	Before cutting	5 years after cutting	Before cutting	5 years after cutting
Sugar maple	45	35	32	41	76	63
Sassafras	32	35	7	35	5	21
Red maple	49	13	12	11	34	12
Black cherry	24	9	0	9	30	17
Beech	14	20	8	15	21	22
Red oak	33	23	0	14	10	12
Black birch	1	7	1	8	0	27
Yellow-poplar	1	9	0	6	0	23

[1/]Percentage refers to the proportion of milacres tallied. Thus "45" following "Sugar maple" means that on 45 percent of the milacres tallied, sugar maple reproduction occurred.

The same is true of yellow-poplar and black birch. Before cutting, seedlings of these two species were almost entirely absent from the stand.

Red maple and black cherry reproduction, on the other hand, apparently suffered from the cutting, at least in the 16-inch and 8-inch cuts. The proportion of milacres stocked with these species declined considerably.

Beech and red oak also are important in the seedling stand. Except for the 13-inch area, there was little change in the stocking of these species.

Discussion

This study must continue for some time before the questions posed are answered. Still, some tentative conclusions can now be drawn for these problems: (1) Are diameter-limit cuttings a desirable method of managing stands for mine timbers? (2) If so, to what diameter should the stands be cut?

Simplicity of application is the big advantage of diameter-limit cutting. Once the limit has been set, the cutter can determine by himself which trees to cut. In practice, however, cutters require about the same supervision and checking on compliance as with a marked stand. There seems to be as much temptation to take a nice tree a little below the diameter limit as there is to cut a good "leave" tree in a marked stand. Therefore, forest management under the diameter-limit system is less costly only because there are no marking costs.

Another advantage of diameter-limit cuttings is that if the limit is high enough (but not too high), both costs and returns per unit volume will be greater because there is none of the expensive handling of low-value small trees.

Both of these advantages are most important in the first cut. Thereafter, the disadvantages begin to show. Compared to the selection system, growth following a diameter-limit cut is considerably less. Dense young stands are not thinned; areas supporting large trees are completely

cut-over; dying small trees are not salvaged; trees of the highest vigor tend to be cut first, while trees of low vigor remain in the stand; slow-growing species tend to be left and fast-growing species cut; the smaller, lower quality trees are left; and there is no control over reproduction. Thus, not only is the total amount of growth less, but also the value per unit of growth is less.

Data are not available from a similar area cut under the selection system. But on another part of the Fernow Experimental Forest, a study exists where a comparison can be made of the growth following a 16-inch diameter limit and a selection-system cutting (2). Board-foot growth during the 5-year period after cutting was 38 percent greater on the selection-system cutting than on the diameter-limit cutting.

Some of the disadvantages already cited could be reduced by changes in the method of management. A flexible diameter limit could be used where desirable trees just above the limit are left and undesirable trees below the limit are cut. Also the diameter limit could be varied with species, site, and stand size. But every step taken in this direction increases the amount of management and more closely approaches the selection system.

After the first cut, management problems become more complex under the diameter-limit system. There is no easy method of planning the cutting cycle and product recovery to maintain a certain diameter limit. To harvest the entire growth over a period necessitates: (1) setting a cutting cycle and adjusting the diameter limit from cut to cut; or (2) setting a diameter limit and waiting until the volume of trees that have grown beyond the diameter limit is equal to the total net growth for the period; or (3) cutting trees throughout a range of diameter classes. The first two alternatives could lead to combinations of cutting cycles and diameter limits that are impractical because of excessive logging costs or high mortality. Selecting the proper combination then requires good judgment and considerable luck. In view of the other drawbacks of a diameter-limit system, it is believed that the last alternative--switching to the selection system--is best.

The question still remains: Which of the three diameter-limit cuttings has given the best results based on the first 5-year period? The 13-inch cutting has put on the best

growth. On the other hand, the 16-inch cutting resulted in lower costs and higher returns per unit volume. If we assume that the net returns given by Weitzman *(3)* can be applied to the annual growth rates, we find that the annual increase in value of the 16-inch area was $4.57 per acre compared to $4.59 for the 13-inch area. So there seems to be little difference between the two. However, since at least part of the better growth on the 13-inch cutting is due to differences in site and in the original stand, the 16-inch cutting may be somewhat more favorable.

It is still too soon to thoroughly evaluate the 8-inch cutting. The growing stock was so reduced that growth, especially that of sawtimber, was lower than that obtained from the other two diameter limits. Returns per 1,000 board feet were also lower. Reproduction was no better than on the other compartments; in fact, there were considerably more sprouts. Therefore it seems to be the least desirable of the three methods.

Summary

In 1950 a study was started on the Fernow Experimental Forest near Parsons, W. Va., to test the suitability of three different diameter-limit cuttings as methods of forest management for the production of mine timbers. Growth and reproduction data are now available for the first 5-year period following cutting. The diameter limits used were 16-inch, 13-inch, and 8-inch.

The best growth during the 5-year period was made in the area cut back to 13 inches. Here the average annual net growth per acre was 2.4 square feet of basal area, or 63 cubic feet. The average annual net growth in board feet per acre in sawtimber trees was 277 as compared to 253 for the 16-inch area, which had more growing stock of sawtimber size.

Actually, the stands following the two lighter cuts were very similar in density of stocking as expressed by either basal area or cubic-foot volume. The better performance of the 13-inch area was due to better site, more favorable stand structure, and removal of the low vigor 14- and

16-inch holdovers from the original stand. These facts, plus the higher net returns, tend to make the 16-inch cutting the better of the two systems.

Despite the low growing stock, the 8-inch cut made comparatively good growth in both basal area and cubic-foot volume. Most of this was ingrowth. Of course, board-foot growth of sawtimber trees was negligible during the first 5-year period. Individual trees grew much faster in diameter than trees of the same size in the other two compartments. However, their growth was still surpassed by the larger trees in the other areas.

Reproduction was plentiful and well-distributed in all three areas. On the whole, stocking by species 5 years after cutting still followed the advance reproduction stocking. Sugar maple was the most abundant and most widely distributed species. Sassafras was also important, becoming even more widely distributed after cutting. Many yellow-poplar and black birch seedlings, almost completely absent before cutting, became established after cutting, especially in the heaviest cuts. Other important species were beech, red oak, black cherry, and red maple. The heaviest cutting produced a large proportion of saplings of sprout origin, now the dominant reproduction in that area.

In view of the poorer growth following cutting, the lack of control over reproduction, the increased management problems, and the tendency to degenerate the stand through repeated cutting of the most vigorous and highest-quality trees and fastest-growing species, the diameter-limit system is very questionable after the first cut. Instead, it is recommended that the first diameter-limit cut be followed by the selection system.

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